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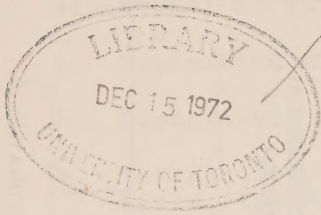
RESEARCH UNDER THE ENVIRONMENTAL
SOCIAL PROGRAM, NORTHERN PIPELINES

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REPORT ON
RESEARCH UNDER THE
ENVIRONMENTAL-SOCIAL
PROGRAM
NORTHERN PIPELINES



MAY 1972

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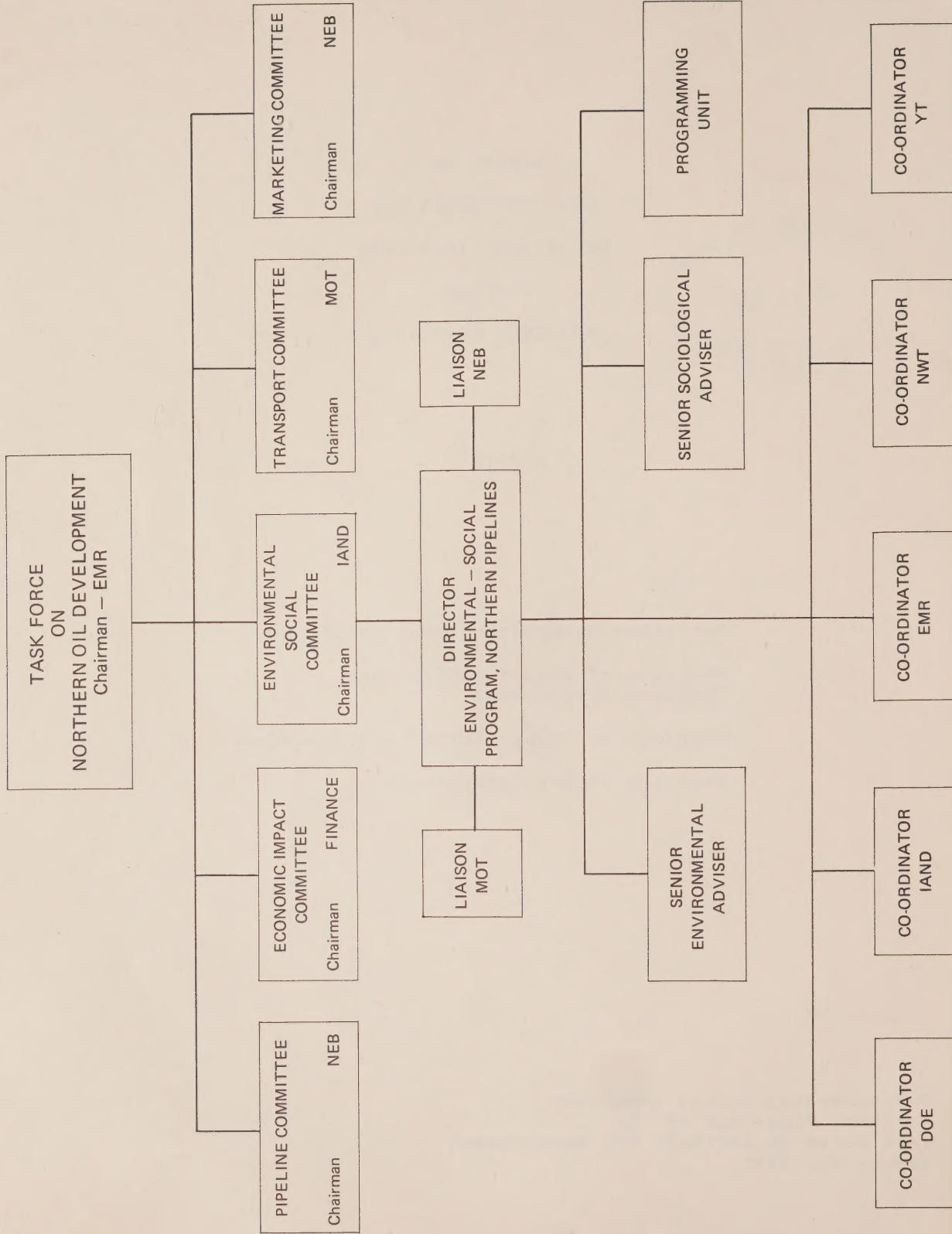


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INTRODUCTION

The Environmental-Social Program functions under the general direction of the Environmental-Social Committee of the federal government's Task Force on Northern Oil Development. The Program was developed to co-ordinate on-going research in various federal government departments on the environmental-social aspects of proposed northern pipelines. Pipeline-related projects from the Department of Energy, Mines and Resources, the Department of the Environment, and the Department of Indian Affairs and Northern Development have been identified and the work is being co-ordinated through the Program. Many existing projects have been expanded and accelerated and new research projects started to look into areas that were not being adequately covered.

The Program now involves the Department of Indian Affairs and Northern Development, the Department of Energy, Mines and Resources, the Department of the Environment, the Ministry of Transport, the National Energy Board and the Governments of the Northwest Territories and the Yukon Territory. The funds for the individual projects, with minor exceptions, are provided for in the budget of the responsible departments or agencies.

The following project reports provide a summary of northern pipeline-related studies undertaken in 1971-72. This work covers a range of disciplines of interest to anyone concerned with potential oil and gas pipelines from the North. These studies were undertaken to establish a context for the development of

government policy. Further details and results of these studies will be published throughout the life of the Environmental-Social Program for distribution to interested members of the public.

For further information on any of the projects contact the Director of the Program or the appropriate responsible Co-ordinator:

Mr. A.J. Reeve,
Director,
Environmental-Social Program,
Northern Pipelines,
Ottawa, Ontario.
K1A 0H4

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Co-ordinator (Energy, Mines and Resources),
Environmental-Social Program,
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Ottawa, Ontario.
K1A 0E4

Dr. E.B. Peterson,
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Environmental-Social Program,
Northern Pipelines,
Ottawa, Ontario.
K1A 0H3

Mr. C.T.W. Hyslop,
Co-ordinator (Indian & Northern Affairs),
Environmental-Social Program,
Northern Pipelines,
Ottawa, Ontario.
K1A 0H4

Director,
Department of Industry and Development,
Government of the Northwest Territories,
P.O. Box 1500,
Yellowknife, N.W.T.

Mr. R. Loewen,
Co-ordinator (Yukon Territories),
Environmental-Social Program,
Northern Pipelines,
Government of the Yukon Territories,
Federal Building,
Whitehorse, Y.T.

1. Project Title: Evaluation of line pipe and pipeline steel.

Project Leader: Mr. S.L. Gertsman
Chief, Physical Metallurgy Division
Mines Branch,
Department of Energy, Mines and
Resources,
568 Booth Street,
Ottawa, Ontario.

(613) 994-5503

Other Professionals on Project

R.C.A. Thurston, D. Bell,
K. Winterton
P. Trudeau, G. Biefer
all of the above address

2. Objectives: (1) To evaluate available line pipe of Canadian and foreign manufacture, with special reference to its performance under Arctic conditions.
- (2) To develop higher strength line pipe adapted to Arctic service.

3. Location: Testing is being done in Ottawa.

4. Progress to Date:

The planning of the assessment project was based on past experience in the investigation of pipe line failures and on knowledge acquired regarding the climatic, installation and operational conditions for the service envisaged. In addition to the standard metallurgical characteristics, it was considered necessary that information be obtained on the residual stress distribution in the fabricated pipe, on its dynamic toughness at low temperatures and its resistance to stress-corrosion cracking, and on the weldability of the pipe with particular respect to the making of girth welds in the field. The planning also included a restricted number of

full-scale burst tests for correlation with laboratory data, and the application of fracture mechanics concepts to the establishment of realistic acceptance criteria for northern line pipe.

It is expected that the pipe will be of the order of 48 in. diameter, with a wall thickness in excess of $\frac{1}{2}$ in. and will be supplied in lengths of about 40 feet. Individual lengths are therefore being procured essentially on this basis. One length of pipe, representing current commercial production, was obtained from the Steel Co. of Canada for comparison purposes. Three lengths, considered to be potentially suitable for use in the North, were obtained from different Japanese pipe mills. Samples of an experimental grade were also obtained from the International Nickel Co. Other Canadian and European suppliers have been contacted. Visual examination and non-destructive inspection of the parent metal and seam weld of some of the pipes has been completed and residual stresses induced by processing have been measured. A metallurgical test program to provide data on property variation along and around the pipe has been prepared and is underway. Weldability studies, using two test techniques, have been made on two of the candidate materials, and the longitudinal weld in the International Nickel pipe has been assessed. A method for simulating welding practices in making a circumferential (field) weld in large-diameter pipelines has been developed.

The planning of the steel development project was based on a study of suitable strengthening techniques and an estimate of the probable metallurgical requirements for northern line pipe. It was considered that direct quenching on the run-out from the hot mill, followed by tempering, was

the most promising procedure. Attention is being concentrated on a low-carbon steel, with and without some alloying elements. A special ingot mould was designed to permit direct rolling in the laboratory without a forging operation, and a direct-quenching facility is being installed on the rolling mill.

5. Proposed 1972-73 Program

Continue investigations as outlined above.

1. Project Title: Topographic mapping and air photography

Project Leader: Mr. R.E. Moore
Chief Topographical Engineer
Surveys and Mapping Branch
615 Booth Street
Ottawa, Ontario

(613) 994-9384

Other Professionals on Project

E.A. Dixon, W.G. Landles
both of the above address

2. Objectives: (1) To provide topographic maps at 1:50,000 scale (including photo maps) of acceptable quality as required for the Environmental-Social Program, Northern Pipelines.
- (2) To provide air photographs required both for producing the topographic maps referred to above and for the various environmental investigations involved in the northern pipeline program.

3. Location: Mackenzie Valley region from provincial boundary to Arctic coast, Tuk Peninsula, and Northern Yukon Territory. Air photography 1970-72 most of this belt; topographic maps of selected map-sheets.

4. Progress to Date:

At the end of the 1971 flying season the air photography was about 50% complete and the A.P.R. profiling was about 80% complete. During 1971, 43 topographic maps at 1:50,000 scale (both line and photo maps) are being prepared using the new air photographs and altitudinal control.

5. Proposed 1972-73 Program

- (1) To complete the air photography.
- (2) To complete the 43 topographic maps commenced in 1971-72 as well as an additional 40 maps.

1. Project Title: Terrain mapping and surficial geology, Mackenzie Delta, Tuk Peninsula and Yukon Coast; G.S.C. Project 690047.

Project Leader: Dr. V.N. Rampton
Terrain Sciences Division
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario

(613) 994-9360

Other Professionals on Project

Nil

2. Objectives: To map describe and explain the surface and near surface unconsolidated earth materials, rock materials, landform features, ground ice and permafrost, and muskeg materials, with particular reference to information required for pipeline, petroleum, and other land use planning, regulation, and development.

3. Location: N.T.S. map-areas 97 F; 107 B,C,D,E;; 117 A,C,D (parts of).

4. Progress to Date:

Inventory of Landforms and Surficial Geology:

Inventory of map-sheets east of the Delta (97 F, 107 C, 107 D, and 107 E) has been completed at a scale of 1:125,000. These maps, plus descriptive notes, will be placed on open file May, 1972. Completion of maps involved airphoto interpretation and three summers of ground checking. The final airphoto interpretation of map-sheet 107 B is being completed and the map should be ready for open file by July, 1972. The

above maps allow an assessment of terrain performance relative to pipeline construction and related activities. Maps could form geological basis for any sort of landuse planning.

Inventory of parts of map-sheets along Arctic coastal plain west of Delta (107C, 117A, 117C, 117D) have been completed at a scale of 1:250,000, and are on open file. These maps are not of the same quality as those from east of the Delta because ground checking was minimal and some of the airphoto coverage is of very poor quality. However, the maps allow one to outline geologically favourable and hazardous zones for pipeline construction, etc. Most areas of aggregate are located. Further ground checking is necessary in order to upgrade the maps to a scale of 1:125,000 and to more accurately describe the map-units and materials (proposed field-work 1972). An areal assessment of bedrock scree as aggregate source is also necessary.

Pleistocene Coastal Stratigraphy:

Comprehensive stratigraphic investigations east of the Delta have been completed, and should be completed west of the Delta in 1972. These investigations not only aid in predicting sub-surface units on land, but may aid in interpretation of offshore geological investigations and aid industry in offshore exploration and development activities.

Inventory of Ground Ice:

The consistent presence of ground ice has been recognized in the

area through direct observation and through compilation of shot hole and engineering test hole logs. (See the following papers - Mackay, 1971; Rampton and Mackay, 1971; Rampton, 1971.) This inventory allows one to predict areas and depths at which any thermal disturbance will have deleterious effects upon the landscape. Further work is necessary to predict the presence or frequency of ground ice under mountainous slopes (proposed field-work 1972). Further development of geophysical techniques relative to the exact location of ground ice is still a requirement (this is being carried out to some degree by Mackay and Hunter): development of such techniques should allow government and industry to more easily assess the presence and amount of ground ice underlying chosen routes and allow for it in construction.

Geological Processes:

Areas susceptible to gullying, slumping, thermokarst, flooding, and coastal recession have been outlined accurately on maps from east of delta, and to a lesser degree from west of the delta (proposed field-work 1972 will upgrade western area to quality of eastern area). Awareness of the above processes, and the areas where they occur will allow industry and government to avoid serious damage to pipelines and related facilities because of these phenomena. Little is known about natural geological processes occurring on steeper mountainous slopes and the hazards they might present to pipelines, etc. Again

it is hoped that his can be investigated during the 1972 field season. Concrete information re sedimentary processes and permafrost profiles under braided channels, which may pose problems to construction, is also lacking, but research into these matters will be initiated in 1972 by B.C. McDonald.

References:

- Mackay, J.R., 1971: The origin of massive icy beds in permafrost, western Arctic Coast, Canada; Can. J. Earth Sci., v. 8, p. 397-422.
- Rampton, V.N., 1971: Ground ice conditions: Yukon coastal plain and adjacent areas; Geol. Surv. Can., Paper 71-1B, p. 128-130.
- _____, 1970: Surficial geology, Herschel Island - Aklavik; Geol. Surv. Can., Open File 21.
- Rampton, V.N., and Mackay, J.R., 1971: Massive ice and icy sediments throughout the Tuktoyaktuk Peninsula Richards Island, and nearby areas, District of Mackenzie; Geol. Surv. Can., Paper 71-21.

5. Proposed 1972-73 Program

In 1972 investigations will be designed to upgrade knowledge and maps for the Arctic Coastal Plain west of the Delta. It will include studies of bedrock and bedrock talus as a source of construction material: stratigraphy of deposits; frequency of occurrence of ground ice under mountain slopes; and geological hazards on mountain slopes and coastal and river-bank areas.

- Open file maps for 97 F and 107 C, D,E, to be released May 1972; that for 107 B in July 1972.
- Revised maps for 117 A,C,D, to be completed early 1973.
- Summary report December 31, 1972.

1. Project Title: Terrain mapping and surficial geology; Central Mackenzie Valley and northern interior Yukon Territory; G.S.C. Project 710020, incorporating Project 690046

Project Leader: Dr. O.L. Hughes
Terrain Sciences Division
Geological Survey of Canada
3303 - 33rd Street N.W.
Calgary, Alberta

(403) 284-0110

Other Professionals on Project

D.A. Hodgson, same address
S.C. Zoltai, Canadian Forestry Service, Edmonton
W. Pettapiece, Canada Department of Agriculture, Edmonton

2. Objectives: (1) To map, describe, and explain, the surface and near surface unconsolidated earth materials, rock materials, landform features, ground ice and permafrost, and muskeg materials with particular reference to information required for pipeline, petroleum, and other land use planning, regulation, and development.
- (2) To arrange integrated terrain surveys in which investigations of soils, vegetation, and some aspects of surface water by personnel of other agencies accompany and complement the geological investigations outlined above.
3. Location: N.T.S. map-areas 106 E,F,I,J,K,L,M,N,O, and 116 I,N,O,P.
4. Progress to Date

During the 1971 field season, field

work was completed for mapping of N.T.S. map-areas 106 I,J,K,L,M,N,O. Map-areas 106 L,M, have been completed to a suitable standard for open file, 106 I,K, have been completed and are receiving final checking; compilation of 106 J is 3/4 completed; compilation of the final interpretation of 106 O is not yet started. A map legend to accompany the maps includes data on vegetation and soils provided by S.C. Zoltai and W. Pettapiece from their observations during the 1971 field season.

Shot hole logs and other borehole data for most of the area have been compiled from industry and government sources, yielding much information on nature of near-surface material and occurrence of permafrost and ground ice.

Mapping during 1969, and 1970 has served as the basis for open file maps at 1:125,000 for 96 C,D,E, and 106 G,H (Open File 26).

References:

Hughes, O.L., and Hodgson, D.A., 1972: Quaternary Reconnaissance northwest District of Mackenzie, Geol. Surv. Can., Paper 72-1A, p. 165-166.

Hughes, O.L. 1972: Surficial geology and land classification, Mackenzie Valley Transportation Corridor; Proc., Northern Pipeline Conference.

5. Proposed 1972-73 Program

Field work will be completed for the balance of the map-sheets during the 1972 season and maps will be prepared for open file for all remaining areas by early 1973. Revision of terrain maps for areas completed in 1969 and 1970 under project 690046 will be done in conformity with the 1971 and 1972 map legends (96 B,C,D,E,; 106 G,H).

1. Project Title: Terrain mapping and surficial geology; Southern Mackenzie Valley region; G.S.C.
Project 710047

Project Leader: Dr. N.W. Rutter
Terrain Sciences Division
Geological Survey of Canada
3303 - 33rd Street N.W.
Calgary, Alberta
T2L 2A7

(403) 284-0110

Other Professionals on Projects

G.V. Minning, same address
C. Crampton, Canadian Forestry
Service, Edmonton

2. Objectives: (1) To map, describe, and explain the surface and near surface unconsolidated earth materials, rock materials, landform features, ground ice and permafrost, and muskeg materials with particular reference to information required for pipeline, petroleum and other land use planning, regulation, and development.
3. Location: Map-areas 85 D,E; 95 A,B,G,H,I,J,K,N,O.
4. Progress to Date:

Quaternary deposits and geomorphology were mapped at a scale of 1:125,000 for map-sheets 85 E (Mills Lake), 95 A (Trout Lake), 95 H (Ft. Simpson), 95 J (Camsell Bend) and the southern half of 95 B (Ft. Liard) during the months of June, July and August, 1971. The selection of map-units and geological data was determined partly by what would be most beneficial to those engaged in pipeline construction and associated activity. A pedological study under the A.L.U.R. program was

prepared by a group from U.B.C. headed by L. Lavkulich along designated traverses covering a variety of terrain, latitude and surficial deposits. The object was to expand the lithologic descriptions of the map-units and to elucidate on soils, vegetation, drainage, and permafrost characteristics. In addition, a forest ecologist, C. Crampton, Department of the Environment mapped the characteristic vegetation of different landforms and surficial deposits.

Shot hole logs and other borehole data for most of the area have been compiled from industry and government sources, yielding much information on nature of near surface material and occurrence of permafrost.

References:

Rutter, N.W., and Minning, G.V., 1971:
Surficial geology and land
classification, Mackenzie Valley
Transportation Corridor; Geol.
Surv. Can., Paper 72-1A, p. 178.

5. Proposed 1972-73 Program

Field work will be completed for the balance of the map-sheets during the 1972 season and maps will be prepared for open file for all remaining areas by early 1973.

- Open file maps for 85 E, 95 A, 95 H, 95 J to be released May 1972. Others late in 1972-73.

1. Project Title: Terrain Sensitivity Evaluation
and Mapping, Mackenzie Valley
Transportation Corridor: 710077

Project Leader: J.A. Heginbottom
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario
K1A 0E8

(613) 994-9348

Other Professionals on Project

Dr. P.J. Kurfurst
(same address)

(613) 994-5435

2. Objectives: (1) To investigate the response of
various earth and rock materials
in differing situations to
various types of ground surface
disturbance, both from natural
and man induced causes.
- (2) To develop and test a terrain
sensitivity mapping system that
will relate the performance or
sensitivity of various terrain
units to the activities of man,
particularly those involved in
the construction and operation
of pipelines.
3. Location: Work in 1971-72 was undertaken in the
areas around Fort Norman, Norman Wells,
Camp Canol, Fort Good Hope and selected
sites in between. Work will be
continued in these areas in 1972-73.
In addition work will be undertaken
around Inuvik, Fort McPherson, Arctic
Red River and selected sites in between.
N.T.S. Map areas 96, 106, 107 (parts of).
4. Progress to Date:
- To achieve the above objectives, a
fourfold approach is being used: (i)

extensive examination and study of sites disturbed at known times in the recent past, or being disturbed at present (this has been in part transferred from project - 690054); (ii) intensive examination and mapping of the engineering - geologic materials of a sample area; (iii) laboratory testing of various soil and rock samples, representing different geological and geomorphological units from both disturbed and undisturbed areas; and (iv) a review of the literature for discussions and descriptions of the effects of engineering activities on terrain, particularly permafrost-terrain.

Field Examination of Disturbed Sites (Heginbottom)

In 1971 work on this aspect of the project was restricted to brief examination of some sites around Norman Wells, Fort Good Hope and Camp Canol. The main achievement of the season was an appreciation of some of the difficulties involved and of the nature of the question that must be asked.

Detailed Geologic Mapping and Laboratory Testing (Kurfurst)

The project began in June 1971. The emphasis of the summer 1971 field season was mainly on general examination and study of all available types of natural and man-caused terrain disturbances in the Norman Wells and Fort Norman areas (the northern parts of NTS 96C and 96D and the southern parts of NTS 96E and 96F). Close attention was paid especially to the old winter roads, seismic and power lines, air strips, borrow pits and similar engineering structures. This general reconnaissance also included investigation of the river banks and land slides in the areas of the potential pipeline crossing along Mackenzie, Great Bear and Brackett Rivers, as well as investigation of prospective drill sites for the 1972 field season.

The rest of the 1971 field season was devoted to the detailed examination and study of specially selected disturbed sites in the Norman Wells area and their comparison with adjacent undisturbed terrain. The selected sites were Canol Road and Canol Pipeline with the old forest fire and borrow pit in the vicinity, freshly built winter road and the drill sites near Oscar Creek Gap and the seismic lines and CNT - line around Norman Wells.

This detailed study, besides extensive description and photo documentation, included measurements of the active-layer thickness and permafrost depth at all disturbed sites and in their undisturbed vicinity and examination of the effects of forest fires. The study also included shallow soil and rock sampling in all areas of interest.

Apart from the detailed visual description, all collected soil and rock samples were tested in the soil mechanic laboratory to determine the engineering index properties (Atterberg limits, moisture content, grain size analysis, etc.) All test results along with the photo-documentation and field observations were carefully evaluated and plotted on the maps.

Most of the results and observations point out that some soil types, especially those with higher ice content are more susceptible to any type of man-induced disturbance than the others. As the sampling and laboratory tests were part of the general study, the number of collected samples and the type of performed tests were not sufficient to supply enough information to draw any final conclusions.

Literature Review (Heginbottom)

The Libraries of the Geological Survey of Canada and the Division of Building Research have been searched fairly thoroughly. The library of the Defence Research Board has been visited once, and further visits are contemplated. Other libraries which it is hoped to visit include

the Departments of Agriculture, Indian Affairs and Northern Development and Public Works.

Several bibliographies and guides to the literature have been scanned. These include:

Annotated bibliography on engineering aspects of muskeg and peat (Canada: NRC/DBR, 1970)

Bibliography of Canadian soil science (Canada Agriculture, 1971)

Bibliography of Alaskan Geology 1950-1959, and 1960-1964 (Division of Geological Survey, College, Alaska, 1971).

Bibliography on snow, ice and permafrost (frozen ground) (U.S. Army Corps of Engineers, SIPRE/CRREL, 1951 to date)

Following the search to date, it is evident that few attempts have been made to study the effect of disturbances on permafrost terrain. There is a considerable amount of material describing the effects of permafrost on civil engineering projects. The problems encountered in Arctic construction and maintenance are well-documented, but little attention has been paid to changes in permafrost conditions following construction. In fact very little was found describing the effect of disturbance on any type of terrain.

The main conclusion is that the only reports in the literature which are of real value to this project are those in which the author has set out to investigate in some measure, the effect of disturbance on terrain conditions. The amount of incidental information in other reports is minimal.

Publications

1. Brief report in G.S.C. Paper 72-1A
2. Heginbottom, J.A. (1972) "Land evaluations at the Geological Survey of Canada", Geographical Inter-University Resource

Management Seminar, Volume 2, No. 3,
January 1972. (Department of Geography,
Waterloo Lutheran University, Waterloo,
Ontario).

5. Proposed 1972-73 Program

Field Examination of Disturbed Sites
(Heginbottom and Kurfurst)

For 1972, we propose to attempt to investigate more sites in greater detail. To assess the differences between the various surficial geologic units being mapped, we propose to examine seismic lines, winter roads and related trails in as many different map unit areas as possible. In assessing the effects of more or less severe disturbance, and the season of the disturbance, we will be restricted to a narrower range of map units, and at this time we are not in a position to predict how successful we are likely to be.

We propose to cooperate with Dr. R.M. Strang (Canadian Forestry Service, Edmonton), who has been instructed to carry out a very similar project in the same area. His area of operation stretches from Fort Simpson to the Arctic Ocean and the Alaska Boundary. Our proposed area of operation is less than this - Fort Norman to Inuvik and the Yukon Boundary. Within the overlap area, we propose, as far as conveniently possible to visit and describe exactly the same sites. In such cases, Dr. Strang's party will concentrate on describing the effects of the disturbance in terms of the peat-mat and the vegetation, while we will concentrate on the soil and surficial material.

Detailed Geological Mapping and Laboratory Testing (Kurfurst)

To provide more specific information on the distribution and properties of soil and rock materials a drilling program will be undertaken. Present plans call for drilling in March and April 1972 to recover frozen samples of material. The drilling will be concentrated

in areas near Norman Wells, Fort Norman and Camp Canol. To obtain the necessary data on ice-content, ultrasonic wave propagation and stress-strain relations will be measured in the rock dynamics laboratory on the representative samples from each geologic unit. The engineering properties of all samples will be determined in the soil mechanics laboratory.

1. Project Title: Preliminary Terrain Classification and Sensitivity Maps

Project Leader: Miss Robin L. Monroe
Terrain Sciences Division
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario
K1A 0E8

(613) 994-5116

Other Professionals on Project

Nil.

2. Objectives: To develop a terrain sensitivity rating and mapping system and to prepare a series of preliminary maps using this system (scale 1:250,000).
3. Location: Mackenzie Valley (provincial boundary to Arctic coast), Northern Yukon, and Tuk Peninsula. Approximately 35 map-sheets are involved in the project.
4. Progress to Date:

Maps have been prepared for 106 M,N; 107 C,D; 107 A (west part) and parts of 117 A,O, but the rating system is still under review. No maps released as yet.

5. Proposed 1972-73 Program

Complete map series.

1. Project Title: Geomorphic processes, Mackenzie Valley-Arctic Coastal Plain, Project 680047

Project Leader: Dr. J.R. Mackay, Professor,
Department of Geography,
University of British Columbia
Vancouver, British Columbia

(604) 228-2257

Other Professionals on Project

C.P. Lewis, Geological Survey,
Ottawa
M.W. Smith, Carleton University,
Ottawa

2. Objectives: To describe, measure and explain geomorphic features and processes related to permafrost, and to fluvial lacustrine, coastal, eolian and mass wasting activity in a permafrost environment.

3. Location: The Mackenzie Valley below Great Slave Lake and the Arctic Coastal Plain.

N.T.S. Map-areas 85, 95, 96, 97, 106, 107 and 117. Most investigations are in the Richards Island-Tuk Peninsula-Mackenzie Delta area.

4. Progress to Date:

This is a continuing project, mainly supported by the Geological Survey of Canada, which has provided much information on permafrost and Arctic geomorphic processes. Investigations in 1971 dealt with pingo-growth, ice-wedge cracking, lake temperature, active layer phenomena, geophysical determination of permafrost thickness, ground temperature profiles, coastal retreat, etc. M.W. Smith investigated permafrost distribution in relation to shift in Mackenzie River channels

and C.P. Lewis studied sedimentation in Mackenzie Delta lakes. Information on many of these topics is contained in Dr. Mackay's published papers on the region. A brief summary of the 1971 work is contained in Report of Activities, 1971, Geol. Surv. Can., Paper 72-1A, p. 193-195.

5. Proposed 1972-73 Program

The investigations listed above will be continued. Studies of offshore permafrost will be conducted in cooperation with J.M. Shearer and J. Hunter.

1. Project Title: Erosion in a permafrost environment:
690054

Project Leader: J.A. Heginbottom
Geological Survey of Canada
601 Booth Street,
Ottawa, Ontario.
K1A 0E8.

(613) 994-9348

Other Professionals on Project

Nil

2. Objectives: To document the nature, extent, and rate of erosion in permafrost areas disturbed by activities of man, and to determine the importance of soil material geomorphology, microclimate, snow cover, vegetation, depth of active layer, ground ice distribution and other factors on controlling erosion.
3. Location: The project is based at Inuvik, N.W.T.
N.T.S. Map area 107 B-7.
4. Progress to Date

Initially the approach was to be threefold: (i) the study of sites disturbed at known times in the recent past; (ii) observation of developments following controlled disturbance of selected natural sites; and (iii) the acquisition and analysis of multiband imagery of selected test sites. The project is based at Inuvik, N.W.T.

Work began in 1969. In that year the emphasis was on approaches (i) and (iii) with particular reference to the area of the Inuvik fire of August 1968. Experiments set up to measure the effect of the fire and of the fire control measures on the elevation and shape of the ground surface and on the thickness of the active layer have been observed each year since. Aerial

imagery of the fire area was acquired in 1969. Preliminary analysis of this has been disappointing.

The direct effects of the forest fire on the permafrost active layer were relatively minor. Over the first few years the active layer became thicker, there was a slight decline in the ground surface elevation and the hummocky microrelief became less pronounced. More serious was the effect of bulldozing of fire-guards, where the vegetation-peat insulating mat was completely removed. The active layer thickened more and quicker, with a marked decline in surface elevation.

Several minor active layer earth flows occurred in the burned area, mainly on south facing slopes. Such flows are common in but not unique to fire areas. The connection between fire and slope failure has not been established.

In 1970 the emphasis of the project was approach (ii). Sites for controlled disturbance were selected and bench marks installed. The disturbance (by bulldozing the surface vegetation and soil) was performed in March 1971, and observations on the effects of this were begun in August 1971. The data is currently being processed.

In 1971, aspects of approach (i) were transferred to a new project (Project 710077). New work included the installation of 12 strings of thermistor beads in the active layer and below. These are designed to monitor the effects of disturbance on ground temperatures in the active layer, to investigate the gradient of various effects across the boundary of a disturbed area, and to consider the difference between hummocks and the intervening trenches. Weekly readings of these installations are being made

on contract, and analysis is underway as data is received. Monitoring of existing experiments was continued.

Publications

1. Brief report in G.S.C. Paper 70-1A
2. Brief report in G.S.C. Paper 71-1A
3. Brief report in G.S.C. Paper 72-1A
4. Heginbottom, J.A.
SOME EFFECTS OF A FOREST FIRE ON THE PERMAFROST ACTIVE LAYER AT INUVIK, N.W.T.; in Proceedings of a Seminar on the Permafrost Active Layer, 4 and 5 May, 1971. (ed: R.J.E. Brown), Canada, National Research Council, Associate Committee on Geotechnical Research, Technical Memorandum No. 103: 31-36, December 1971.
5. Heginbottom, J.A.
Aspects of the thermal regime of the permafrost active layer at Inuvik, N.W.T. (in preparation).

5. Proposed 1972-73 Program

The existing experiments will be continued. No new major experiments are proposed. Some test drilling at the sites of the existing experiments will be undertaken to recover information with regard to the physical, engineering and ground ice contents at these sites. Other minor observations are planned also.

1. Project Title: Engineering Geology, Mackenzie Valley
Transportation Corridor, Project
700094.

Project Leader: Dr. R.M. Isaacs
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario
K1A 0E8

(613) 994-5657

Other Professionals on Project

J.A. Code
Same address as above

2. Objectives:
- (1) The development of criteria for the measurement and prediction of the interrelationships between engineering construction and terrain performance.
 - (2) The delineation of engineering characteristics of terrain units in terms of engineering index properties, ground ice content, thermal transfer properties and performance as foundation or construction materials.
 - (3) The identification and evaluation of the mechanics and rates of active geomorphological processes (slope movement, erosion, sediment transport).
 - (4) The evaluation of techniques for the recovery of frozen soil samples from boreholes.
 - (5) The development of methods of instrumentation for the evaluation of the thermal properties of soils.
3. Location: Mackenzie Valley, mainly in Fort Good
Hope-Norman Wells areas.

4. Progress to Date:

The field component of this project consisted in part of geological reconnaissance, the development and evaluation of drilling techniques in permafrost for the recovery of frozen soil samples, and an assessment of the performance of small drilling machines and light-weight split-spoon sampling equipment. Other parts of the field program involved (1) a study of the slopes and river bank erosional processes along sections of the Mackenzie River and its tributaries, (2) an evaluation of a specific area for granular material for construction purposes, (3) the establishment of a field laboratory for standard soil classification tests as well as thermal tests on frozen soil samples, and (4) the permanent installation of instrumentation in boreholes.

This work was done in the Fort Good Hope and Sans Sault Rapids map-areas.

In drilling for the recovery of frozen soil samples, a modified diamond drill was used and the drilling liquid temperature was lowered and maintained within specified limits by means of a chiller unit.

All boreholes were logged and representative samples and cores were tested in the field laboratory. A thermal laboratory, supervised and staffed by personnel from the Seismology Division of the Earth Physics Branch, made measurements of thermal conductivity and thermal diffusivity on selected samples of frozen core. Equipment used was the "divided bar" and "needle probe", the latter being specially adapted to limit the temperature rise of the probe.

Thermister cables were installed in 5 boreholes and temperature readings were taken at intervals through the winter.

5. Proposed 1972-73 Program

- (1) Further drilling, collection of frozen cores, and laboratory testing of the cores, and continuation of other activities commenced in 1971.
- (2) Development of computer program to permit calculation of the position of the thawing isotherm under a variety of conditions.

1. Project Title: The stability of natural slopes in the Mackenzie Valley.

Project Leader: J.A. Code
Geological Survey of Canada
601 Booth Street,
Ottawa, Ontario.
K1A 0E8.

(613) 994-5198

Other Professionals on Project

Nil

2. Objectives: To achieve an understanding of the behaviour of the river banks in a permafrost environment as they retreat, and by this understanding to predict the significance of the stability of slopes with respect to future engineering activities particularly those associated with pipeline and other resource developments.
3. Location: The Mackenzie River and its tributaries between Fort Providence and Point Separation, N.W.T. N.T.S. Map areas 85 D,E; 95 H,I,J,N,O; 96 C,D,E; and 106 H,I,J,M,N,O.
4. Progress to date:

The work under this project was begun in 1971 as part of project 700094: Engineering Geology, Mackenzie Valley Transportation Corridor (See separate report, this publication). In 1971 the reach of the Mackenzie River between Sans Sault Rapids and the mouth of the Ontaratie River was investigated. A report on this work was presented at the Canadian Northern Pipeline Research Conference, Ottawa, 2-4 February, 1972.

5. Proposed 1972-73 Program

In 1972 the program will comprise reconnaissance mapping of river banks between Fort Providence and Sans Sault

Rapids. The work will involve identification of the types and scales of river bank failure and determination of the relationships between the future characteristics and the geological environment, the engineering properties of the soil and rock materials, the geometry of the slopes, the boundaries of permafrost and the nature of the erosional processes acting on the river banks.

1. Project Title: Geophysical Investigation of Permafrost

Project Leader: Dr. J.A. Hunter
Dr. J.E. Wyder (resigned Sept. 1971)
Geological Survey of Canada
Department of Energy, Mines and Resources,
601 Booth Street,
Ottawa, Ontario.

(613) 994-5125

Other Professionals on Project

Nil

2. Objectives: To test application of shallow seismic techniques, resistivity techniques, and borehole logging techniques in determining the presence or absence of permafrost, the top and bottom of permafrost, and occurrence of ground ice or ice-rich sediments.
3. Location: In 1971 Tuktoyaktuk, Sans-Sault Rapids, and Fort Simpson areas. Additional areas in Mackenzie Valley and northern Yukon in 1972.
4. Progress to Date:

Borehole geophysical measurements were made in 7 drill holes in the Tuktoyaktuk and Sans-Sault Rapids areas, using the following sondes: neutron thermol-neutron, decentralized gamma-gamma, 3-arm caliper, and natural gamma.

Seismic and resistivity surveying was done near Tuktoyaktuk in April and sites were reoccupied again in August to investigate seasonal differences in effectiveness of techniques in the continuous permafrost region. Seismic and resistivity profiles were also made in the Fort Good Hope and Fort Simpson areas and compared with borehole data.

5. Proposed 1972-73 Program

- (1) Seismic and resistivity profiles in conjunction with terrain mapping projects various areas.
- (2) Repeat seismic profiles in the Tuktoyaktuk area and additional profiles in the Mackenzie Delta (J.A. Hunter).
- (3) Reflection seismic and resistivity profiles offshore by J.A. Hunter in conjunction with J.M. Shearer to locate offshore permafrost.

1. Project Title: Geothermal studies,
Mackenzie Valley Region.

Project Leader: Dr. A.S. Judge
Seismology Division
Earth Physics Branch
Department of Energy, Mines and
Resources
Ottawa, Ontario.

(613) 994-5459

Other Professionals on Project

Nil.

2. Objectives: To provide information on the geothermal regime and the thermal properties of near surface materials in the Mackenzie Valley region, as part of the ongoing study of heat flow by the Earth Physics Branch.

3. Location: Various sites (boreholes) along Mackenzie Valley and in adjoining region.

4. Progress to Date:

Nine boreholes 400-1, 100 m deep have been preserved for temperature observations relating to terrestrial heat flux and the lower boundary of permafrost. In connection with the Geological Survey program in The Fort Good Hope area, thermister cables were constructed and installed in 4 boreholes during the summer and temperatures read at monthly intervals. Sixty measurements of thermal conductivity were made on Geological Survey core material using divided bar equipment operated in a trailer at Fort Good Hope.

5. Proposed 1972-73 Program

- (1) To increase the number of thermal conductivity determinations, in particular to examine the variations with temperature in more detail; measurements will also be made on cores returned to Ottawa from Fort Simpson, Fort Macpherson and Norman Wells, as well as further work on the Fort Good Hope cores.
- (2) To put the acquisition of thermal diffusivity measurements on core samples on a production line basis.
- (3) To continue the monitoring of both deep and shallow drill holes.
- (4) To continue analysis of the thermal regime to determine heat flows and past surface temperature changes.
- (5) When sufficient data are available for the thermal regime and the thermal parameters, it will be possible to model the regime and determine whether or not mass transfer plays a role in the real conditions.
- (6) It will also be possible to model the effects of disturbing influences such as pipelines on the thermal regime.

1. Project Title: Earthquake hazard along pipeline routes.

Project Leader: Dr. A.E. Stevens
Seismology Division,
Earth Physics Branch
Department of Energy, Mines and
Resources
Ottawa, Ontario

(613) 994-9158

Other Professionals on Project

As required.

2. Objectives: (1) As part of the continuing study of seismicity in Canada, to determine the focal parameters of significant earthquake occurrences in and near the proposed pipeline routes, utilizing records from the Canadian Seismic Network.
- (2) As part of the continuing study of engineering seismology in seismically active areas of Canada, to estimate probable ground acceleration and response spectra.

3. Location: Entire area.

4. Progress to Date:

Seismic studies of the Yukon and Mackenzie Valley have been and are being made as part of a continuing investigation of Canadian seismicity. Earthquake catalogues for the years 1899 to 1965 have been published and 1966 is in press. The 1970 seismic zoning map for Canada, based on data from 1899 to 1963, includes the Yukon-Mackenzie regions. No information is available prior to 1899, since no written history of the area exists

and since a world-wide network of seismic stations was developed only in the early 1900's. Catalogues of Canadian earthquakes from 1967 to the present are being prepared. The seismic history from 1967 to the present is known for earthquakes of magnitude 5 and greater from the epicentre lists of the N.O.A.A. (U.S.A.) based on international data to which the Canadian seismic network contributes.

For structures of good design and construction (without additional earthquake-resistant features) a risk of significant earthquake damage begins normally with earthquakes of magnitude 6 or greater, although some magnitude 5 earthquakes have been damaging. The seismic history of the Yukon-Mackenzie region is complete from 1900 to the present only for major earthquakes (mag. > 7) and is probably complete from 1930 to the present for potentially damaging earthquakes (mag. ≈ 6). Only with the establishment of a network of Canadian Arctic stations in the early 1960's has it been possible to detect and locate all earthquakes in the region down to magnitude 4. This magnitude threshold may be lowered to 3 and the precision of earthquake location improved with the establishment of the first permanent Yukon seismic station at Whitehorse in September 1971. (A seismic station at Inuvik, N.W.T., just north of the Yukon has operated since March 1969.)

The information available includes earthquake catalogues and their interpretation, and detailed calculations of future seismic risk based on the known seismic history.

5. Proposed 1972-73 Program

Processing of seismic data will be continued at an accelerated rate.

Additional information on earthquakes in the Yukon may be obtained during a 6-week regional seismicity survey in the summer of 1972 in which temporary seismic stations will be operated at 5 sites in the Yukon and adjacent N.W.T.

1. Project Title: Surficial Geology and Geomorphology,
Mackenzie Bay Continental Shelf:
700092

Project Leader: J.M. Shearer
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario
K1A 0E8

(613) 994-9360

Other Professionals on Project:

Nil

2. Objectives: To map, describe and explain the unconsolidated deposits, associated organic remains, geomorphic and structural features and permafrost occurrence in order to: (1) provide areal geological knowledge including information required in connection with petroleum exploration and production; (2) determine Quaternary (glacial and post glacial time) stratigraphy and history; and (3) identify the sedimentary and geomorphic processes operating in the area.

3. Location: Near-shore offshore area, Alaska-Yukon Boundary to Cape Bathurst including channels in outer portion of Mackenzie Delta.

4. Progress to Date:

Ship-board work on Hudson * and Richardson in 1970 and North Star in 1971 has provided echo-sounder and shallow seismic profiles, side-scan sonar records, and core and grab samples of bottom materials for much of the near-shore area outlined above. These data and their interpretation have provided reconnaissance information

on sea-bed materials, sub-bottom stratigraphy, offshore permafrost, ice-scour, and coastal and offshore environmental history. Some of the results are contained in publications:

Oil week, Nov. 15, 1970
G.S.C. Paper 71-1A pp. 242-244,
1971
G.S.C. Paper 71-1B pp. 131-138,
1971
Science Vol. 174 pp. 816-181,
Nov. 19, 1971
G.S.C. Open file 58, 1971
G.S.C. Paper 72-1A pp. 179-180
D.P.W. Arctic port Study, 1971

Proposed 1972-73 Program

Investigations as above will be continued, involving North Star and Parizeau, and will be directed particularly to (1) sediment temperatures and off-shore permafrost and (2) collection of cores at selected localities to confirm nature and sequence of sediments as inferred from echo sounder and seismic profiles.

* Associated investigations by B.R. Pelletier;
C. Yorath.

1. Project Title: Mackenzie-Porcupine River Aquatic Ecology related to Gas and Oil Pipeline Development.

Project Leader: Dr. J. G. Brunskill
Fisheries Research Board
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba R3T 2N6

(204) 269-1420

Field office: Fisheries Research Board
P.O. Box 3333, Yellowknife, N.W.T.
(403) 873-4275

Other Professionals on Project:

Dr. N. Snow (Mackenzie Delta);
Mr. G. Vascotto (Porcupine River, headwaters of Arctic Red and Peel Rivers, and North Slope Yukon Rivers);
Mr. D. Rosenberg (Mackenzie main-stem and tributaries from Trout River to Arctic Red River); Dr. R. Wagemann, Winnipeg Laboratory.

2. Objectives:
- (1) To assess the distribution, abundance and diversity of aquatic organisms (primarily zoobenthos) which occur in regions subject to future development.
 - (2) To assess the range of natural variation in physical and chemical parameters that influence the growth of aquatic organisms mentioned above.
 - (3) To assess the effect of increased silt loads on the aquatic ecology of rivers and streams.
 - (4) To assess the effect of oil on the aquatic ecology of rivers and streams.

3. Location:

In 1971, four field teams covered the area from the beginning of the Mackenzie River at the outlet of Great Slave Lake to the Mackenzie Delta, and the Porcupine River - North Slope watersheds. These teams were based at Fort Simpson, Inuvik, and Old Crow, with substations at Norman Wells and Arctic Red River. Samples and experiments were done from river scow, helicopter and fixed-wing aircraft. General field headquarters was in Yellowknife, where chemical laboratory, office, and storage facilities were built.

4. Progress to Date:

Construction activities associated with pipeline installation will likely cause increased thermal erosion in areas of permafrost. This may result in increased silt loads in streams, rivers and lakes. Therefore, the first phase of our program is a study of the chemistry of suspended and bottom sediments, and the benthic organisms that live in these environments. The second phase will be a study of the effects of crude oil on aquatic ecosystems in the pipeline route.

Suspended sediment transport rates varied from less than 10 tons/day (Great Bear, Willow Lake Rivers) to greater than 100,000 tons/day (Peel, Arctic Red, Redstone, lower Mackenzie, Liard Rivers). With the exception of some of the smaller humic acid colored rivers draining to the Mackenzie from the east, most rivers carried calcite and dolomite in suspension. This would act as a buffer to acidic waters introduced by disturbance. Bottom sediments varied from

greater than 1 meter diameter boulders to clays. Many clear rivers to be crossed by proposed pipelines have high banks of fine alluvial or lacustrine sediments. The ability of the river to transport these construction-associated bank erosion products will depend on discharge and water velocity, both of which are strongly seasonal.

Studies on zoobenthos in these rivers revealed in general a greater diversity and abundance of organisms in the clear rivers compared to the very turbid rivers, especially in the Porcupine and Peel River watersheds. However, in some cases, rivers transporting large amounts of suspended sediment support populations of supposedly silt-sensitive organisms (Simuliidae larvae in the Liard River). In the Mackenzie Delta, turbid lakes appeared less productive than the more permanent, clearer lakes. These delta lakes supported a much greater abundance of zoobenthos than the East and Middle Channel (Mackenzie water), and in the West Channel (Peel River water) very few organisms were collected with our sampling gear.

In general, we tentatively recommend that pipeline routes avoid the major clear, low-velocity rivers. Presumably, increased silt loads would have less effect on benthos in turbid, high-velocity rivers than in clear, low-velocity rivers.

The types of information on Mackenzie and Northern Yukon watersheds that is currently on file in the Freshwater Institute, Winnipeg, but which is not yet sufficiently complete for publication includes:

- a) Physical and chemical data on rivers and streams.
1. Temperature of water.
 2. Turbidity, conductivity and/or salinity.
 3. Suspended sediment (ss) quantity (g/l, tons/day).
 4. Suspended sediment mineralogy.
 5. Organic matter (% C, N) in suspended sediment.
 6. Elemental composition of suspended sediment.
 7. Mineralogy and particle size of bottom sediment.
 8. Organic matter in bottom sediments.
 9. Elemental composition of bottom sediments.
 10. Data of 7, 8, 9, on shore and river bank soils.
 11. Chemical composition of filtered water samples (major elements: Ca, Mg, Na, K, HCO_3 , Cl, SO_4 , H; nutrients: total dissolved N, P, and Si, particulate N and P. trace elements: limited data on Cu, Zn, Cd, Fe, Mn, Pb, As, Al).
 12. Velocity and discharge for some streams not monitored by Water Survey of Canada.

b) Biological data

1. Taxonomic groups of aquatic organisms associated with the sampling station locality
2. Numbers of organisms per unit area of sediment
3. Biomass or weight of living organisms per unit area
4. Identification of organisms in fish stomachs
5. Reference collection of specimens of aquatic insects and other aquatic organisms
6. Rates of colonization of artificial substrates by benthos
7. Drift organisms (animals in the water column)
8. Adult insects which have emerged from their larval stages in streams
9. Results of tests of different sampling gear

5. Proposed 1972-73 Program

Studies will concentrate on small areas around Ft. Simpson, Inuvik and Old Crow. Some experiments on the effect of crude oil on small streams and lakes are planned. This will be done in conjunction with fishery ecologists. Studies on the effects of increased silt loads will continue and this will require continued support from Water Survey (discharge and velocity measurements).

1. Project Title: Fish Resources of the Mackenzie River Valley.

Project Leader: Mr. C.T. Hatfield
Fisheries Service
Dept. of the Environment
114 Garry Street
Winnipeg, Manitoba

(204) 985-5437

Other Professionals on Project:

M. Falk, C. Jessop, J. Millen,
and J. Stein, all of the above address.

2. Objectives:
- (1) To determine species composition, distribution, age, growth, feeding, length-weight and spawning characteristics of fish stocks.
 - (2) To obtain baseline data on contamination of fish with heavy metals and pesticides.
 - (3) To compile a stream catalogue covering chemical and physical water quality, water flows, spawning gravel areas, and major obstructions to fish migration.
 - (4) To assess sport and commercial fishing potential and native sustenance fishery requirements.
 - (5) To conduct food intake studies that will indicate which food sources are particularly vulnerable to disruption and at which times of year this could be critical to fish survival.
 - (6) To carry out bioassays for potential pipeline flushing and testing materials.

3. Location: Studies are located along the entire length of the Mackenzie River, with base camps at Arctic Red River, Norman Wells and Fort Simpson. Synoptic surveys by helicopter are covering all Mackenzie tributaries that could be crossed by currently proposed routes.

4. Progress to Date:

Substantial fish runs were found in the Peel, Mackenzie and Arctic Red rivers in 1971. Over thirty species of fish were regularly caught. Arctic char, Dolly Varden, lake trout, inconnu, humpback and broad whitefish, cisco, northern pike, walleye and Arctic grayling appeared to be the species which could be most affected by construction of a northern pipeline.

Fish distribution varied widely depending on the species. Arctic grayling, for example, were found throughout the system but inconnu only in the main channels.

Age and growth and age class composition data for some northern fish species appear comparable to those of more southern commercially fished species. Based on stomach analyses, it appears that some fish such as chub and trout-perch, normally considered not valuable, are important forage fish for the economically important inconnu, pike, walleye and lake trout. Terrestrial insects make up a large portion of the diet of many fish species during the summer months.

Spawning areas for the various fish species are extremely difficult to pin down. Tributary streams flowing north into the Mackenzie between Great Slave Lake and the junction with the Liard River are very important for grayling

spawning as are some clear running streams around Norman Wells area. Large migrations of inconnu, humpback and broad whitefish and Arctic and least cisco, south through the delta area, indicate spawning takes place at some points upstream, particularly in the Arctic Red River. Generally, it appeared that the clear east side Mackenzie streams were more important than the turbid west side streams for fish production. These streams would be particularly suitable for sport fishing. The delta area has the potential for a commercial fishery. Sizeable native sustenance fisheries exist in the delta area and around many settlements throughout the valley.

5. Proposed 1972-73 Program

Specific spawning, nursery and feeding areas will be further delineated in 1972. Migration routes and times will also be better determined and population estimates verified by a tag and recovery program. More emphasis will be put on lakes along the pipeline routes in the Mackenzie Valley and delta region.

In addition, laboratory bioassay experiments investigating effects of pipeline flushing chemicals on fish, and field experiments simulating stream disruptions at pipeline crossings will be carried out. Intensive study of some small representative stream systems is planned.

1. Project Title: Fish Resources of the Northern Yukon.
- Project Leader: Mr. A. Gibson
Fisheries Service, Pacific Region,
1090 West Pender Street
Vancouver 5, B.C.
- (604) 666-3611

Other Professionals on Project:

J.E. Bryan, M. Elson, R. Kendal,
L. Steigenberger C.E. Walker,
J.A. Summers, B. Landeen, all of
the above address.

2. Objectives:
- (1) The overall objective of the program is to protect the productivity level of the aquatic ecosystems at levels no lower than those measured in 1971 and 1972. To this end the studies were designed to provide a qualitative and quantitative assessment of the indigenous fish stocks.
 - (2) To determine the dependence of residents on the fish stocks.
 - (3) To quantify some characteristics of the streams relevant to fish reproduction.
 - (4) To become familiar with pipeline construction and operation techniques in order to identify the manner in which and degree to which the various industrial activities may adversely affect the environment.
3. Location: Studies are located along two routes that have high priority in the Yukon Territory at this time. One follows the coastal plain on the Beaufort Sea and the second route crosses approximately 120 miles south of the coast through the socially important Old Crow area.

4. Progress to Date:

The period of continuous survey extended from July 22 to September 9. During that time one base camp was maintained at Old Crow on the Porcupine River. Gill nets were operated 5 days per week in order to obtain a continuous sample of fish populations. During July and August a base camp was also maintained on Herschel Island. From this camp crews flew to streams along the Beaufort Sea drainage in order to sample fish, invertebrates, chemical characteristics, and physical characteristics of streams. In late August all personnel were moved to Old Crow which was then used as a base for similar stream survey work in the Porcupine River drainage. Samples were taken at 115 stations on 57 streams and all major streams flowing into the Beaufort Sea and all major tributaries of the Porcupine River were visited.

In streams of the Beaufort drainage, the most common fish species is grayling. Streams near the Mackenzie River have larger populations of whitefish and greater species diversity than western streams. The Babbage River and streams west of it have greater densities of Arctic char than those to the east. As a result, the potential commercial and sport fishery value of western streams is higher than that of eastern ones. In the Beaufort drainage round whitefish, broad whitefish, northern pike, ninespine stickleback, as well as grayling and char were captured.

There were some interesting differences in chemical and physical characteristics of streams east and west of the Babbage River.

The western streams were generally higher in p^H (7.5-8.5), total alkalinity

(86-150 ppm) and total dissolved solids (100-150ppm) than the eastern streams. This suggests that the annual productivity of western streams would be higher at all trophic levels. Moreover, the western streams generally had gravel better suited to grayling, char and whitefish spawning.

Gravel in many eastern streams consisted of fine shale containing much sediment. In most streams of the Beaufort drainage the area between the 300 and 1,500 ft. contours contained the most suitable salmonid spawning gravel. The oxygen concentration of the streams along the Beaufort drainage was usually saturated and the 5-day BOD was low (less than 1 ppm). The concentration of phosphate and nitrate was also low (less than 0.2 ppm). Chemical characteristics of streams in the Porcupine drainage were usually similar to those of the western Beaufort.

In rivers of the Beaufort drainage, the standing crop of macro-invertebrates was usually greater near the headwaters than near the mouths. In both drainages mayfly larvae, caddisfly larvae and various diptera larvae were observed. Micro-invertebrate, or periphyton, samples were collected for use as indicators of environmental change.

The fish fauna of the Porcupine drainage is more diverse than that of the Beaufort. although grayling is again the predominant species in many areas. In the Porcupine drainage, grayling, broad whitefish, round whitefish, humpback whitefish, least cisco, inconnu, longnose sucker, northern pike, burbot, troutperch, lake chub, slimy sculpin, as well as chinook, coho, and chum salmon were caught. The fish fauna of the Porcupine drainage

was generally denser than that of the Beaufort, presumably reflecting greater annual productivity at all trophic levels.

The major salmon spawning streams are the Miner River and the Fishing Branch River. Young chinook salmon were captured in the Miner River although spawning grounds were not located. In several short-term surveys, adult chum and coho salmon were counted in the Fishing Branch River where the total run is estimated to be in excess of 250,000.

Salmon, whitefish and grayling are particularly important as food fish to the residents of Old Crow. These fish, plus suckers, also form the basic food for dogs. An estimated 10,000 - 20,000 chum salmon are taken annually.

5. Proposed 1972-73 Program

A continuing assessment on population sizes and activities could be carried out in some areas, particularly near Old Crow, in order to manage the commercial, recreational, and subsistence fisheries. Later priority will be placed upon surveys of the marine resources of the Beaufort Sea and on the fish populations inhabiting the Peel River system.

1. Project Title: Hydrometric Measurements in the Mackenzie River Basin

Project Leader: Mr. K.F. Davies
Water Survey of Canada
700 Calgary Power Building
110 - 12 Ave. S.W.
Calgary, Alberta

(403) 266-1631

Other Professionals on Project

R.D. May, G. Morton
both of the above address

2. Objectives: (1) To provide basic hydrometric data to indicate possible flood magnitudes.
(2) To provide river level forecasts.
(3) To document grain size and sediment conditions in fish reproduction areas.
3. Location: Mackenzie River at Beaver Lake, Providence, Head of Mills Lake, Head of Line, Rabbitskin River, Fort Simpson, Camsell Bend, Wrigley, Norman Wells, Sans Sault Rapids, Fort Good Hope, Near Arctic Red: Kakisa River at outlet Kakisa Lake; Trout River near mouth; Liard River near mouth and at Fort Liard; South Nahanni River above Clausen Creek; Willowlake River near mouth; Redstone River near mouth; Arctic Red River at Martin House; Peel River near Fort McPherson; Firth River near mouth. Staff will be based at three sub-offices at Fort Simpson, Norman Wells and Inuvik. A sediment laboratory is being established in Hay River to analyse the sediment samples collected in this study.
4. Progress to Date:

As of 1955 there were only nine hydrometric stations operating north of the 60th

parallel, two of which provided stream-flow data. Sediment and water quality data were not collected. By the end of 1970, 36 stations were operating in the Mackenzie Basin north of the 60th parallel, 27 providing streamflow data, but no sediment data.

During 1971, the following additional work was undertaken.

- (1) Five continuous water level recorders on the Mackenzie River for water level forecasting as an aid to navigation.
- (2) Sediment discharge data collected at one site on the Mackenzie and one on the Liard River.
- (3) Three other sites constructed and ready for 1972 operations.

5. Proposed 1972-73 Program

Plans for 1972 include:

- (1) Upgrading of three additional stations on the Mackenzie to full discharge, and sediment data collection.
- (2) Begin collecting sediment data on 5 or 6 tributaries to the Mackenzie in addition to present discharge data.
- (3) Establish an additional 4 to 6 stream gauges on presently ungauged tributaries to the Mackenzie to collect stage-discharge and sediment data.

1. Project Title: Hydrologic Implications of Northern Pipelines

Project Leader: Dr. D.K. Mackay
Hydrologic Sciences Division
Dept. of the Environment
No. 8 Temporary Building
Ottawa K1A 0H3

(613) 994-5047

Other Professionals on Project:

J.C. Anderson, J.R. Anderson,
S. Fogarasi, J. Gilliland,
R.L. Harlan, W.E.S. Henoch,
O. Loken, J.R. Mackay, C.D. Sellars,
M. Spitzer, K. Swami, T. Thakur,
all of the above address.

2. Objectives:
- (1) To identify and assess hydrologic factors affecting or interacting with pipelines at river crossings.
 - (2) To identify and assess hydrologic factors affecting or interacting with pipelines in drainage basins; to examine the physical limnology of a selected number of lakes along proposed pipeline routes.
 - (3) To evaluate groundwater and permafrost conditions in the Mackenzie River Valley Region and to establish from a groundwater point of view the probable effects of groundwater-permafrost interactions on the construction and safe operation of a pipeline.
3. Location: Regional hydrology of Mackenzie Basin and northern Yukon with emphasis on areas that may be affected by pipeline construction.

4. Progress to Date:

Project content for objective (1) has included mapping of ice shove heights, location and extent of ice jams, areas of rough ice, ice shearing and polynas, levels of winter ice and gravel exposures, bed scour and bank erosion, snowmelt runoff and summer storms, icing on streams and dendrochronology. Some Mackenzie ice shove and ice jam data are available, air photo interpretation of fluvial geomorphology on lower reaches of Mackenzie tributaries are nearly complete, and documentation of an extreme storm condition, July 1970, is in final stages.

Project content for objective (2) has included measurements of water supply, water budget, basin morphometry and hydrologic relations among sub-basins, distribution of aufeis, effects of berm construction, thermal characteristics and bathymetry of lakes. Progress to date has included establishment and partial instrumentation of 3 research basins, some lake data recorded and available, and Mackenzie basin morphometry is one-half complete.

Project content for objective (3) has included hydrogeological studies aimed specifically at providing essential background data needed to assess the effects of a transportation-pipeline corridor on the existing groundwater-permafrost regime and documentation of seasonal groundwater pressure fluctuations and rates of groundwater recharge and discharge. A reconnaissance hydrogeological and aerial photograph interpretation study of the Mackenzie River Valley region is in progress. Limited drilling programs have been completed at Norman Wells and Inuvik, N.W.T., and instrumentation installed for the study of coupled mass heat transfer in permafrost regions.

5. Proposed 1972-73 Program

Work outlined above will continue
throughout 1972-73.

1. Project Title: Water Quality Studies in the Mackenzie Basin and Northern Yukon.

Project Leader: Mr. D.R. Silliphant
Water Quality Division
Department of the Environment
308 Brent Building
2505 11th Avenue
Regina, Sask.

(306) 523-4691

Other Professionals on Project:

P. Fee and S. Reeder both of
Water Quality Division
Department of the Environment
725 - 11 Avenue S.W.
Calgary, Alberta

(403) 264-5118

2. Objectives: (1) To determine the present water quality on the Mackenzie River and its major tributaries.
- (2) To monitor the changes in water quality in the Mackenzie River system that occur during the development of pipeline, road, rail, and urban facilities in the corridor.
- (3) To provide water quality information to other agencies involved in environmental studies.

3. Location: Porcupine River at Old Crow; Peel River at Fort McPherson; Mackenzie River at Fort Providence, above Fort Simpson, at Norman Wells, below Arctic Red; Arctic Red River near Arctic Red; Great Bear River near mouth and at outlet of Great Bear Lake; Redstone River near mouth; Willowlake River near mouth; Liard River at Fort Liard, at Nahanni Butte and near mouth; Trout River at Highway # 1; Hare Indian River near mouth; Ramparts, Mountain, Keele, North Nahanni

and Horn Rivers near mouth; Blackwater River at outlet of Blackwater.

4. Progress to Date:

A network of 24 sampling locations has been established within the survey area. Seven of these stations are located on the Mackenzie River. Water samples are collected at prescribed frequencies for on-site analysis and for laboratory analyses. The following analyses are conducted on site: temperature, p^H , conductance and dissolved oxygen. The following analyses are conducted in the laboratory: temperature, p^H , conductance, turbidity, color, alkalinity, hardness, suspended material, nitrates, total nitrogen, orthophosphates, total inorganic phosphates, total phosphorus, calcium, magnesium, sodium, potassium, iron, sulphate, chloride, fluoride, silica, manganese, copper, lead, zinc, cadmium, arsenic, mercury, nickel, molybdenum, cobalt, selenium, boron, vanadium, chromium, strontium, total organic carbon and total inorganic carbon. In addition, checks are completed periodically for pesticides and hydrocarbons.

A computer printout of the limited results to date is available upon request.

5. Proposed 1972-73 Program

In 1972-73 sampling will continue as outlined above.

1. Project Title: Mapping of Wildlife Habitat and Animal Concentrations.

Project Leader: Mr. G. Watson
Pipeline Mapping Co-ordinator
Canadian Wildlife Service
515 Centennial Building
10015 - 103 Avenue
Edmonton, Alberta

(403) 429-5811

Other Professionals on Project:

Mr. W. Prescott (moose studies);
Mr. R. Poston (waterfowl studies);
Mr. M. Dennington (fur-bearer studies);
Mr. R. Glasrud (Arctic fox, bear, Dall sheep, and barren-ground caribou studies),
all of the above address.

2. Objectives: (1) To produce a series of 34 map sheets integrating data on wildlife habitat, wildlife migration, and wildlife concentration areas, in order to provide (a) information for land use planning for pipeline construction and other major construction projects in the North, and (b) to provide information suitable for pipeline proposal evaluation studies. Each map will be a self-contained unit, with a legend. The map series will be supported by data concerning important wildlife areas.
- (2) To outline habitat units of a certain value to wildlife, and migration areas and routes of migrating animals. The habitat units, which are large landscape units, will be rated, for each species, according to a four class system based on their quality.

- (3) To prepare separate habitat maps for the following species of wildlife: Arctic fox, barren-ground caribou, beaver, Dall sheep, grizzly bears, moose, muskrat, shorebirds and waterfowl.

3. Location: A total of 34 map sheets (at a scale of 1:250,000) covering the Mackenzie Valley Region from the Alberta-N.W.T. border along both banks of the river and then widening at Fort McPherson to include the Old Crow drainage and the Arctic coastline from the Alaska-Yukon border to Observation Point on Baillie Island.

4. Progress to Date:

Preliminary maps have been made on the basis of September and November 1971 reconnaissance of the area.

5. Proposed 1972-73 Program

Further reconnaissance and mapping will be undertaken in 1972-73.

1. Project Title: Mackenzie Valley Terrain Sensitivity Studies

Project Leader: Mr. S.C. Zoltai
Canadian Forestry Service
Northern Forest Research Centre
5320 - 122nd Street
Edmonton 70, Alberta

(403) 435-7210

Other Professionals on Project:

Dr. R. Strang and Dr. C. Crampton
both of the above address

2. Objectives:
- (1) To determine the relationships between landform, vegetation cover and permafrost in subarctic and northern alpine environments.
 - (2) To map landform-potential vegetation types.
 - (3) To determine (1) the reactions of arctic and sub-arctic vegetation and soil to various disturbances, and (2) techniques contributing to the maintenance and restoration of surface stability.
 - (4) To integrate this work with results emerging from studies of the Geological Survey of Canada, Canadian Forestry Service, Canadian Wildlife Service, ALUR projects and others to enable the devising of a terrain sensitivity classification for land use regulations.
3. Location: Mapping project covering area of all proposed pipeline routes within Yukon and Mackenzie Territories.

4. Progress to Date:

Approximately 20,000 square miles were reconnoitered and mapped in the southern Mackenzie River valley and 25,000 square miles in the northern part of the valley, in co-operation with the Geological Survey of Canada.

In the discontinuous permafrost areas vegetation and landforms form a reliable basis for predicting permafrost conditions. In the continuous permafrost area vegetation can be used to characterize near-surface permafrost and active layer conditions. Soil texture and slope may be used to estimate the ground ice content.

Disruption of the living vegetation and the organic mat will cause a deepening of the active layer during the summer. This will result in subsidence, as the ground ice melts. On slopes earth flows and slides can be initiated.

5. Proposed 1972-73 Program

Reconnaissance survey and mapping of entire study area. Detailed investigation of areas disturbed at various times by man-made or natural causes.

1. Project Title: Vegetation Mapping of the Mackenzie Valley and Northern Yukon

Project Leader: Mr. W.L. Wallace
Forest Management Institute
Department of the Environment
Majestic Building
396 Cooper Street
Ottawa K1A 0H3

(613) 995-6311

Other Professionals on Project:

R.P. Hirvonen, R. Piirvee and P. Gimbarzevsky, all of the above address.
Dr. Patricia Roberts-Pichette on contract for literature review.

2. Objectives: (1) To map and describe the existing forest and non-forest vegetation in the study area at a scale of 1:125,000 (approximately 2 miles per inch). To do this some fourteen vegetation types are being delineated and classified on recent small-scale air photos, transferred to base maps and verified during field work.
- (2) To generate maps that will provide data and basic information necessary to appraise the sensitivity of the environment to disturbance. This appraisal is being undertaken mainly by the Northern Forest Research Centre, Edmonton. The maps and generalized descriptions of the vegetation types will also provide a suitable base for assessing wildlife habitats, and the productivity and commercial value of the lands for forestry and recreational purposes.

- (3) To have prepared, under contract, a literature review and annotated bibliography relating to permafrost-vegetation landform relationships in arctic and sub-arctic regions of North America and Eurasia.
- (4) To investigate the feasibility of developing a computer mapping and information retrieval system for C.F.S. and other agencies.

3. Location: First priority mapping is being undertaken in a strip, from 25 to 50 miles wide, along currently proposed pipeline routes from the Alberta border to the vicinity of Fort McPherson, along the Yukon north coast and through the Porcupine drainage from Fort McPherson to the Alaska-Yukon boundary. Second priority mapping is planned in a wider band on both sides of the narrow first priority corridor.

4. Progress to Date:

During July and August 1971, a reconnaissance of the first priority area was carried out to allow the interpreters to gain some familiarity with the vegetation types and to collect data on which to base a suitable classification. Provisional interpretation and mapping of this first priority area will be completed by March 31, 1972.

About 700 line miles of special colour infra-red photography was obtained under contract since this type of imagery is especially suited for interpreting vegetation types.

5. Proposed 1972-73 Program:

Continued reconnaissance and refinement of maps in the first priority area and mapping of second priority area.

1. Project Title: Land Use Information Map Series
- Project Leader: Miss S.G. de Belle
Land Use Planning Branch
Lands, Forests and Wildlife Service
Trebla Bldg., 473 Albert St.,
Ottawa
- (613) 992-0729 or 994-5363

Other Professionals on Project:

P.H. Beaubier and S.D. Thomson,
both of the above address.
The Lands, Forests and Wildlife
Service of Environment Canada has
undertaken the preparation of the
series of land use information maps
on behalf of, and through financial
support from, the Arctic Land Use
Research Program of the Department
of Indian Affairs and Northern
Development.

2. Objectives:
1. To produce a series of 44 land use information maps that integrate a wide range of data on renewable resources and related activities.
 2. To contribute, by means of these maps, to the information base required for (a) administration of the Land Use Regulations under the Territorial Lands Act, (b) regional planning, land-use planning and land management in the North (c) evaluation of studies associated with proposals for pipelines and other industrial projects.
3. Location: There is a total of 44 map sheets (at a scale of 1:250,000), of which 35 cover the Mackenzie River valley from

the Fort Liard and Tathlina map sheets at 60° N to the Mackenzie Delta map sheet and nine cover the Northern Yukon from the Eagle River and Porcupine map sheets north to the Beaufort Sea. This mapped area is approximately 200,000 square miles.

4. Progress to Date:

Information was largely compiled from existing data, derived mainly from Federal and Territorial agencies. New information was obtained from interviews with hunters, trappers and other northern residents.

- (a) Wildlife - extent and characteristics of important and critical wildlife areas, habitat function and seasonal use; sanctuaries, game preserves or reserves, proposed wildlife range; notes on hazards to wildlife.
- (b) Hunting and Trapping - areas hunted and/or trapped; game management zones.
- (c) Fish Resources and Fishing - fish migration routes, fish spawning areas or potential areas; notable domestic and commercial fishing areas; notes on hazards to fish.
- (d) Recreation - Tourism - areas of recreation - tourism interest; recreation-terrain regions and rating values; campgrounds, roadside parks and picnic sites; sports fishing areas, lodges and camps; big game hunting, outfitter areas and base camps.
- (e) Proposed reserves of the International Biological Programme.
- (f) Archeological and historical sites.

- (g) Extent of Development Areas, existing and proposed Development Control Zones and D.N.D. property.
- (h) Other - location of hydrometric and water quality stations; capped gas wells and oil wells, up-dated transportation and communications network; climatic data; fur statistics; demographic data and statement of functional basis of communities.

Research information is "superimposed" on topographic base information. Each map is a self-contained unit, accompanied by a detailed legend and explanation. Data collection, which began in June 1971, has been completed for more than 30 maps; data collection is 90% complete for the remainder. Twenty-three complete sheets (N.W.T.) have been assembled and are in the drafting stage. Remaining sheets are partially assembled and all assembling is scheduled for completion by mid-April. Cartographic work on all 44 maps is scheduled for completion on 19 May. Thirty-five map sheets will be printed between April 1 and May 16; the remaining 9 maps will be printed between May 23 and late June.

5. Proposed 1972-73 Program:

The final stages of cartography and the final printing of these maps will be the only activity on this project in 1972-73. An updating program, to begin in 1973-74, is being considered for this map series.

No reports, other than the maps themselves, are planned. All maps will be printed and available for public distribution by late June 1972. Copies of these maps are available from:

Map Distribution Office,
Surveys and Mapping Branch,
Department of Energy, Mines and Resources,
615 Booth Street,
Ottawa, K1A 0E9.

Att: Mr. L.M. Sebert

1. Project Title: Waste Disposal Study

Project Leader: Mr. J.W. Grainge
Environmental Protection Service
Department of the Environment
257 Federal Public Building
Edmonton

(403) 424-0251

Other Professionals on Project:

A. Gunter and J. Greenwood
of the above address, and
J. Shaw, Dept. of Health and Welfare,
Ottawa.

This work has been undertaken on
behalf of, and with financial
support from, the Arctic Land Use
Research program of the Department
of Indian Affairs and Northern
Development.

2. Objectives:
- (1) To examine and define waste disposal problems in the North with particular reference to gas and oil pipeline development.
 - (2) To assess any existing installations which are considered to have potential value for waste disposal.
 - (3) To plan and execute any necessary research and development work.
 - (4) To make recommendations as to regulations respecting waste disposal.
 - (5) To demonstrate, if necessary by research and development, that the recommended standards can be met.

3. Location: In general, the Mackenzie River basin and the Northern Yukon. Information is being collected from a wide geographic sampling of current cold region waste disposal practices.

4. Progress to Date:

(1) Development of solid waste disposal regulations

Preliminary drafts of proposals for regulations have been prepared and these proposals will be the basis of discussions with various government departments and agencies, oil companies operating in the north, and the various consortia involved with northern pipeline studies. The objective during these discussions is to evaluate the environmental ramifications of the following solid waste disposal systems:

- (i) sanitary landfill,
- (ii) modified sanitary landfill,
- (iii) shredding, compaction and landfill,
- (iv) incineration and burial of landfill,
- (v) backhaul on otherwise empty freight equipment,
- (vi) garburation of kitchen waste and disposal to an oxidation pond with or without spray irrigation to dispose of pond effluent and/or digested sludge.

(2) Development of waste water disposal regulations and guidelines.

Information has been gathered on processes available for sewage treatment in the Arctic and sub-Arctic and alternatives have been outlined for discussion. This information will be included in an interim report that will discuss the applicability of the alternative to Arctic use and their environmental side-effects, together with brief outlines of design criteria, estimates of

capital and operating costs and probable research and development needs.

5. Proposed 1972-73 Program:

Solid waste disposal investigations will continue with particular attention given to the potential for air pollution from incineration because temperature inversions develop more frequently in the inland valleys of the western Canadian Arctic than elsewhere in Canada's north. Methods for disposal of residual ash, costs of this disposal and the attraction of animals to incompletely burned organic material will be investigated.

In the field of waste water disposal, both regulations and guidelines will be developed. The regulations will specify the criteria necessary for environmental protection. The guidelines will contain technical information - recommended design criteria, construction principles and operating procedures - which will most probably meet the regulation requirements and which are most appropriate to Arctic operations. For example, proposed criteria for wastewater lagoons have already been published.

Adequate consideration of these Arctic design fundamentals will be expected of all plans submitted for approval. It is expected that approval of all engineering plans will be a prerequisite of camp construction, and provision for adequate testing, inspection and maintenance of all sanitary facilities will be included with these plans.

There is also expected to be a requirement for the equivalent of secondary treatment for sewage from all pipeline camps under normal anticipated conditions. However, there will be discretion to relax this

requirement under certain circumstances. The public health and environmental effects of raw sewage disposal from temporary camps in isolated areas are not clearly defined. Alternatives involving disposal on land, in swamps and small natural lakes with no significant recreational or gamefish values will be investigated to assess the real public health and environmental risks imposed by these schemes.

Attention will be given to transport alternatives for water and water-borne sewage. Heavy trucks, which could be used to haul water and sewage, may cause damage to terrain and to lake or river water sources. Such trucks would also require the construction of extra, and probably undesirable, roads. Therefore, to limit environmental damage it is considered preferable to transport water and water-borne sewage by pipe. There will be a study of existing pipe installations and, if necessary, experimental models will be established. The end objective of this investigation will be to recommend construction details for water and sewer pipes buried in various soils under permafrost conditions.

1. Project Title: Archaeological Studies

Project Leaders: Mr. R. Wilmeth,
Head, Salvage Section,
Archaeological Survey of Canada,
National Museum of Man,
Ottawa, Ontario.
K1A OM8

Mr. R.E. Morlan,
Yukon Archaeologist,
Archaeological Survey of Canada,
National Museum of Man,
Ottawa, Ontario.
K1A OM8

Other Professional on Project

Mr. J. Cinq-Mars,
(at the above address)

2. Objectives: (1) To carry out a general survey and
identify areas of archaeological
or historical importance.

(2) To assess the significance of
selected sites by field survey.

(3) To excavate significant known
sites.

3. Location: Mackenzie River Valley and Northern
Yukon.

4. Progress to Date

Preliminary work only in 1971-72.

5. 1972-73 Program

Phase 1. An exhaustive literature
search covering scientific
and historical literature
relevant to the archaeology
of the area and preparation
of an annotated bibliogra-
phy to guide field studies
and other further work.

Phase 2. Detailed study of topographic maps and aerial photographs to define priority areas.

Phase 3. Field surveys in selected priority areas and excavation of significant sites. (Present knowledge suggests that at least four areas will require immediate field work.)

Phase 4. Analysis of collections and preparation of reports.

1. Project Title: Energy Budget Components in an Arctic Environment.

Principal Investigator:

Dr. D.M. Gray,
Chairman,
Division of Hydrology,
University of Saskatchewan.

Associated Investigator:

Mr. J.R. Radforth,
Muskeg Research Institute,
University of New Brunswick.

2. Objectives: (1) To evaluate the energy budget components over disturbed and undisturbed terrain in the tundra region.

(2) To classify and quantify levels of terrain disturbance by relating them to changes in energy budget components.
3. Location: Vehicle test sites at Tuktoyaktuk. Additional sites in the Mackenzie Delta.
4. Results to Date:

(It is presupposed that the extent of damage associated with a given surface disturbance depends on the corresponding change in net energy absorbed by the ground. Thus, it will be possible to relate the extent of damage to changes in energy budget components and, perhaps, to develop a predictive model.)

Instrumentation has been designed, built and tested by the Division of Hydrology, University of Saskatchewan which will permit the automated measurement of radiation, temperature and humidity at 5 minute intervals for periods of up to 21 days. The readings are recorded on tape which can be interfaced directly with a computer.

A quasi-quantitative scale of terrain damage has been developed by the Muskeg Research Institute based on observations during the 1970 and 1971 summer field seasons at vehicle tests sites at Shingle Point, Tununuk and Tuktoyaktuk. The scale reflects the extent of damage to vegetation and the formation, nature and depth of ruts.

5. 1972-73 Program:

The instrumentation developed by the University of Saskatchewan will be used to measure the energy budget components at a number of sites of terrain disturbance, including the vehicle test sites at Tuktoyaktuk and selected newly disturbed areas, and on adjacent undisturbed tundra. The results will be used to develop a more objective way of assessing and predicting the extent of terrain damage associated with different types of surface disturbance.

1. Project Title: Land Base Oil Spills
- Project Leader: Dr. J. Riddick,
Manager,
Arctic Land Use Research Program,
Department of Indian Affairs and
Northern Development,
Room 1038,
400 Laurier Avenue W.,
Ottawa, Ontario.

Principal Investigators:

Dr. D.W.S. Westlake,
Dr. F.D. Cook,
Department of Microbiology,
University of Alberta.

Dr. T.C. Hutchinsin,
Dr. J. Hellebust,
Department of Botany,
University of Toronto.

Dr. D. Mackay,
Dr. M.E. Charles,
Dr. C.R. Phillips,
Department of Chemical Engineering,
University of Calgary.

Dr. D. Parkinson,
Department of Botany,
University of Calgary.

Other Professionals on the Project:

Dr. J.C. Wood,
Industrial and Engineering Services,
Research Council of Alberta,
87th Avenue & 114th Street,
Edmonton, Alberta.
(until 31/3/72)

2. Objectives: (1) To examine and define the problems
created by crude oil being spilled
on land in the North.
- (2) To plan and initiate any necessary
research and development work
including studies concerning:

- (a) The capacity of the soil microflora of the Mackenzie Valley to degrade crude oils originating in the North.
- (b) The effect of crude oil on boreal terrestrial and aquatic vegetation.
- (c) The behaviour of crude oil on frozen ground and in snow.
- (d) The applicability of conventional containment and clean-up procedures to northern circumstances.
- (e) Methods of detecting pipeline leaks.

3. Location: In general the Mackenzie River basin and the northern Yukon. Most of the field work will be carried out in the vicinity of Norman Wells, N.W.T. Laboratory work will be carried out in the laboratories of the participating investigators.

4. Progress to Date;

- (1) A general appraisal of the problems associated with oil spilled in the Arctic has been done and a report has been prepared.
- (2) A preliminary investigation has shown that the biodegradability of crude oils from Prudhoe Bay, Norman Wells and Atkinson Point is variable. Norman Wells oil degrades readily, Atkinson Point shows signs of being resistant and that from Prudhoe Bay appears to exhibit intermediate behaviour. A contract has been arranged to study these phenomena comprehensively.

Another contract has been arranged to study the short and long term effects of crude oil spills on terrestrial and aquatic vegetation.

- (3) A third contract has been arranged which will study some of the physical parameters concerned with the movement of oil on frozen ground and in snow.
- (4) A feasibility study has been carried out into the possibility of detecting oil spills in water by making use of the oil's natural fluorescence. A report on this study is expected soon.

5. Proposed 1972-73 Program:

- (a) Detailed investigations will be conducted into the microbiological degradation of crude oils from Prudhoe Bay, Atkinson Point and Norman Wells. These studies will concern:
 - the capability of northern soil micro-organisms to degrade crude oil,
 - the effect of crude oil on soil micro-flora and fauna,
 - the effect of degraded oil on the region's biological system.

This will be done by Drs. Westlake and Cook at the University of Alberta and Dr. Parkinson at the University of Calgary.

- (b) An extensive investigation will be conducted into the effect of crude oil on aquatic and terrestrial vegetation in the North. Here the objectives will mainly centre on elucidating the response and recovery capabilities of boreal vegetation affected by oil and will include such topics as:

The comparative effects of spills occurring at different seasons.

The composition and numbers of phyto and zooplankton and the way they are influenced by oil.

An examination of the biota in the vicinity of natural seepages.

The overall aim will be to determine survival and recovery capabilities of organisms exposed to oil.

This work will be done by Drs. Hutchinson and Hellebust at the University of Toronto.

- (c) An investigation will be conducted into the behaviour of crude oil on frozen ground and in snow. Measurements will be made of the rate of flow of oil and absorption into snow and ice.

Weathering characteristics of oil will be assessed as will its absorption/adsorption behaviour on land.

Calculation will be made on the extent of fire hazards. Data will be gathered relevant to clean-up techniques.

This work will be done by Drs. Mackay, Charles and Phillips at the University of Toronto.

The projects outline in (a), (b) and (c) above will be integrated as closely as possible and to a large extent will be conducted in the same general area. Together they will represent the major portion of the program's efforts in the coming year.

1. Project Title: Vegetation Studies in the
Lower Mackenzie River Region.

Principal Investigator:

Dr. L.C. Bliss,
Department of Botany,
University of Alberta.

Associated Investigator:

Dr. R.W. Wein,
Department of Botany,
University of Alberta.

2. Objectives: (1) To assess the extent of surface disturbance and its relation to vegetation cover and soil condition.
- (2) To evaluate the potential of native species for revegetation of disturbed areas.
- (3) To investigate the potential of seed mixes (agronomic and native species) for revegetation of severely disturbed sites, including winter roads, airstrips and other bare soil surfaces.
3. Location: Mackenzie Delta Region (1971 study sites near Inuvik, near Tuktoyaktuk, at Atkinson Point and at Tununuk Point).

4. Results to Date:

Landscape units based on the relationship of topography, soils, soil drainage and plant communities have been defined for the Mackenzie Delta region including Richards Island and the Tuktoyaktuk Peninsula. The classification was based on an examination of aerial photographs (1:20,000) combined with ground checking and detailed study of vegetation and soils at selected sites. Examination of surface

disturbances (seismic lines and winter roads) has demonstrated that the extent of damage and the rate of recovery cannot be generalized, but are quite different for different landscape units.

The factors which affect plant productivity have been investigated and it has been demonstrated that in general low soil temperature is a more important limiting factor than the availability of moisture or soil nutrients. However, plant growth and seed head production are enhanced in native species by the application of nitrogen and in introduced species by the application of phosphorous or phosphorous with nitrogen.

Techniques of revegetation have been investigated with reference to suitable species, the use of seed mixes, soils, location, time of year to plant and fertilizer treatments. 16 species were test planted in 1970 and 7 remained vigorous after the first winter. Results to date indicate that reseeding should be done in the early spring prior to run off and suggest that seed mixtures (including mixture of native and introduced species) may perform better than single species.

5. 1972-73 Program:

Studies of revegetation will continue, to identify the most suitable species, fertilizer levels, etc. Four native species will be included in the field tests which will be conducted near Norman Wells as well as at previously established sites in the Mackenzie Delta Region. Attention will be directed to the environmental requirements of the species in completing their life cycle, especially seed production which will enhance long term survival and the effect of soil temperatures and nutrient requirements as these relate to specific types of disturbance including hot and cold pipeline right-of-ways.

1. Project Title: Disturbance Studies in the Mackenzie River Region.

Principal Investigators:

Dr. D.E. Kerfoot,
Department of Geography,
Brock University.

Dr. J.D.H. Lambert,
Department of Biology,
Carleton University.

Mr. J.R. Radforth,
Muskeg Research Institute,
University of New Brunswick.

2. Objectives:
- (1) To assess the relative tolerance of various terrain types by monitoring the changes in vegetation and near-surface soil layers that accompany modifications of the surface conditions of the terrain.
 - (2) To analyse and evaluate the long term effects of tundra disturbance resulting from the movement of equipment and vehicles.
 - (3) To determine the rate of stabilization of the active layer and the rate and sequence of plant succession following surface disturbance.
 - (4) To correlate the observed changes with particular "levels of disturbance" as a basis for prediction in the future.

3. Location: Mackenzie Delta Region:
In 1971, studies were carried out at the following sites: Shingle Point, Tununuk Point, Tuktoyaktuk (vehicle test sites); Shingle Point, Sitidgi Creek (132° 49'W, 68° 40'N), Jimmy Lake (133° 47'W, 68° 40'N) (Winter Roads);

Parson's Lake area, Jimmy Lake Area (summer seismic lines); Caribou Hills area near Reindeer Station, Banks Island (winter seismic lines); Storkerson Bay, Banks Island (drill rig site).

4. Progress to Date:

Quantitative measurements of destruction of vegetation and soil microrelief, soil temperature, soil ice content, depth of thaw, thermokarst and subsidence have been made at a number of sites on the winter roads and summer seismic lines. Qualitative observations and inspections have been made on some additional summer seismic lines and on the winter seismic lines.

For winter roads, field observations suggest that the ice road method of construction is much more effective than the snow packing technique in limiting the level of terrain damage, but additional research is necessary to determine the number of years that the same access route should be used.

Observation on the winter seismic lines has demonstrated that with adequate care, surface operations can be carried out with minimal terrain damage. Correspondingly, on-site investigations suggested that it is possible to move equipment and vehicles on the tundra in summer without causing serious damage, the real problem centres on the weight and type of vehicle and the maximum number of vehicle passes that the ground can tolerate before the degree of disturbance exceeds acceptable levels.

As a general point, it has been demonstrated that destruction of surface microrelief leads to uniformity of thaw penetration and restoration of those

features will take a far longer period than will be required to re-establish a continuous vegetation cover.

In August 1971, six profiles of the undisturbed terrain conditions were made across the proposed rig site at Storkerson Bay: these profiles will, in the future, permit an evaluation of the terrain disturbances incurred as a result of drilling operations.

Tracked vehicle test sites were established in 1970. Observations were made in 1970 and again in 1971 to determine the effect of vehicle weight, number of passes, season at which the traffic is run and turning radius.

5. 1972-73 Program:

Observations will be continued on the summer seismic lines, the winter road at Shingle Point, the rig site at Storkerson Bay and the vehicle test sites to evaluate the long term effects of surface disturbance and the rate of recovery.

In order to generalize the present results on winter roads and seismic lines, measurements will be extended to experimental manipulation plots. Manipulations will include: trampling or dissection of the vegetation cover; removal of living organic matter; removal of complete organic layer, shredding and replacement on surface of the plot; removal of complete organic layer and exposure of mineral soil.

In addition to the above work which will be carried out in the Mackenzie Delta Region, assistance will be provided to the Canadian Forestry Service for their Mackenzie Valley Terrain Sensitivity Studies.

4. Progress to Date:

Material on hand has been organized.
A manual card index is being prepared.
Micro film of the Alyeska submission
is on hand, and has been reviewed with
a micro film reader available for
viewing this material.

5. Proposed Program 1972-73:

Continue 1971-72 program.

1. Project Title: Disturbance Studies in Boreal Forest Region, Mackenzie River.

Principal Investigator:

Dr. L.M. Lavkulich,
Department of Soil Science,
University of British Columbia.

Associated Investigators:

Dr. D.S. Lacate,
Department of Geology,
University of British Columbia.

Dr. J.S. Rowe,
Professor of Plant Ecology,
College of Agriculture,
University of Saskatchewan.

2. Objectives: (1) To supplement terrain reconnaissance surveys being undertaken by the Geological Survey of Canada by providing more detailed land inventory and assessment of selected areas in the Mackenzie River region.
- (2) To investigate the relationships between geologic materials, soils, vegetation and landforms.
- (3) To contribute to the development of a methodology for assessing terrain sensitivity.

3. Location: In 1971, work was carried out at four locations near Fort Simpson, N.W.T., namely:

| | <u>Latitude</u> | <u>Longitude</u> | <u>Area (sq. miles)</u> |
|--------------|-----------------|-------------------|-------------------------|
| Mills Lake | 60°15' - 62°00' | 119°20' - 119°40' | 570 |
| Camsell Bend | 62°40' - 62°55' | 122°10' - 123°10' | 340 |
| Trout Lake | 60°00' - 60°31' | 100°30' - 100°40' | 350 |
| Camsell Bend | 62°05' - 62°20' | 122°20' - 123°20' | 340 |

4. Progress to Date:

A preliminary inventory of geologic materials, soils and landforms in the four areas was carried out using available aerial photography. Ground truth and detailed pedological and ecological studies of the terrain were then carried out by interdisciplinary teams of ecologists, foresters and pedologists; the field parties also collected vegetation, soils and water quality samples for laboratory study.

Special attention was given to the relationship between soils, vegetation and landforms and the inventory was, therefore, established on a geologic material basis within which units of landforms, soils and vegetative succession are assigned. The inventory has been mapped on aerial photographic mosaics (scale 1 inch to 1 mile). Each mosaic has its own legend and, in addition, more detailed descriptions of the soils and associated vegetation have been prepared (including selected chemical and physical properties of the major soil types).

Observations were also made on the relationship between the distribution of plant communities and the occurrence of ground frost; as anticipated, they are intimately related to water and temperature regimes which are largely determined by the conduction and capacity properties of the soil system.

The four areas investigated consist largely of organic terrain with associated organic soils. An organic landform classification system has been proposed based on that of Tarnocai (Classification of Peat Landforms in Manitoba, Mines Report, Canada Department of Agriculture Research Station, Pedology Unit,

Winnipeg, 1971). In general bogs are underlain by ice at relatively shallow depths, whereas fens do not appear to be underlain by ice.

The vegetation is predominantly aspen poplar, white and black spruce, jackpine, lodgepole pine and tamarack. The lesser vegetation consists of mosses, lichens, bog birch, horsetails, hedges and various herbs and shrubs.

Results from the study have been made available to the Geological Survey of Canada for incorporation in their general terrain classification program.

5. 1972-73 Program:

A similar program will be undertaken in 1972-73 in selected areas near Wrigley, N.W.T.

1. Project Title: The Socio-economic Impacts of Large Diameter Pipeline Construction in the Northwest and Yukon Territories.

Project Leader: A.T. Jordon,
Head, Resources and Transportation
Section,
Northern Economic Development
Branch,
Department of Indian Affairs
and Northern Development,
400 Laurier Avenue West,
Ottawa, Ontario
K1A 0H4

(992-8629)

2. Objectives: The objectives briefly stated are as follows:

- To determine the social and economic benefits and costs to the Territories of large diameter pipeline(s) construction and maintenance in the Territories with specific reference to pipeline proposals to link oil and/or gas discoveries on the North Slope of Alaska with United States markets.
- To provide Federal and Territorial governments with adequate information to develop policies and programs to maximize on any benefits accruable to northern residents and to minimize on any possible detrimental effects to northern economies and the general well-being of resident populations.
- To assess the impact of pipeline development on non-renewable and renewable resources and their future development in the Territories.

3. Location: Ottawa, Winnipeg, Whitehorse and Yellowknife.

4. Progress to Date:

The basic data collection requirements for this project have been completed. Matrices for benefit cost studies and projections have been developed and are being tested. Projections are based on a no pipeline case and five alternative pipeline cases based on routing alternatives. Base data are currently being analyzed and a draft report is being assembled.

5. 1972-73 Program:

June 15 - draft report

July 31 - Final report

1. Project Title: Information storage and retrieval system.

Project Leader: L.C. Munn,
Head, Programming Unit,
Environmental-Social Program,
Northern Pipelines,
400 Laurier Avenue West,
Ottawa, Ontario.
K1A 0H4

(992-3123)

2. Objectives: (1) To collect material directly related to the decision making process in connection with northern pipelines. This would include:
- (a) reports on relevant research in the Canadian north, carried out by universities, research centres, industry, and government.
 - (b) reports (both progress and final) on special research projects initiated by the Environmental-Social Program.
 - (c) material about other northern pipeline proposals, e.g., Trans Alaskan Pipeline, detailed description, Department of the Interior Impact Statement and information on further developments.
- (2) To organize and catalogue this material, paying particular attention to a detailed subject analysis, so as to make immediately available all information on a particular topic.

3. Location: Ottawa

1. Project Title: Northern Pipelines Northwest Territories Development Plan.
2. Objectives:
 - to develop policies for recommendation to the Federal Government with regard to the pipeline;
 - to develop policies for implementation by the Territorial Government;
 - to develop a detailed plan of action for ensuring that the pipeline will bring maximum benefit to the Northwest Territories, and minimum disruption.
3. Location: Northwest Territories section of the pipeline route.
4. Results to Date:

This project is still in its early stages, since much of the detailed work will require more specific knowledge than is now available on how the pipeline will be built and operated. It will also depend on outputs from the socio-economic study being carried out by the Department of Indian Affairs and Northern Development.

Close liaison is being maintained with the Department of the socio-economic study, and some input has been provided.

Policy recommendations have been developed. A check list has been drawn up covering a wide range of matters which will have to be handled by various Government agencies to provide needed services to Territorial residents. Sub-studies which will be required to meet the objectives of this project have been identified and assigned. Consideration has been given to the organization that will be required during the construction period to fulfill the functions assigned to the Government of the Northwest Territories.

